



## Effect of Altitudes on Soil and Vegetation Characteristics of *Pinus roxburghii* Forest in Garhwal Himalaya

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**Abstract:** The present study was conducted in *Pinus roxburghii* forest in the District Tehri Garhwal of Uttarakhand State to assess the soil properties, forest species composition and volume along altitudinal gradients. The study revealed that the moisture content and water holding capacity of soil increased with increasing altitudes while bulk density (BD) reduced with increasing altitude. The higher proportion of soil texture was contributed of sand > clay > silt in each altitude. The soil pH of entire forest was acidic in nature. The soil organic carbon (SOC) and nitrogen increased with increasing altitude. Phosphorus and potassium has not shown any trend with altitude. The associated shrubs in *Pinus roxburghii* forest were *Rhus parviflora*, *Carissa opaca*, *Berberis aristata*, *Lantana camara* and *Rubus ellipticus*. The highest and lowest density of *P. roxburghii* was recorded in top and middle altitude respectively. The total basal cover (TBC) and volume of *P. roxburghii* was reduced with increasing altitude.

**Keywords:** Altitude, Soil and Vegetation, *Pinus roxburghii*.

### 1. Introduction

Vegetation is a key factor in determining the structure of any ecosystem. Within a plant community, it determines microclimate, energy budget, photosynthesis, water regimes, surface runoff and soil temperature (Tappeiner and Cernusca, 1996). The plant community in a region is a function of time and altitude, slope, latitude, aspect, rainfall and humidity also play an important role in the formation of plant communities and their composition (Kharkwal *et al.*, 2005).

Quantitative analysis of vegetation helps in understanding the structure, composition and the tropic organization of any community. Species composition and diversity vary from one habitat to another within the communities exposing identical physiognomic characteristics (Nautiyal *et al.*, 1999).

The Garhwal Himalaya is one of the hot spots of biodiversity, situated in the western part of Central Himalaya. The wide altitudinal range and rapid change in altitudinal gradient even at small distances and high

endemism make it interesting for studies (Singh *et al.*, 1992; Zobel and Singh, 1997).

The vegetation diversity of forest ecosystems of Himalaya is influenced by topography, soil, climate and geographical location of the region. There is a great diversity in the floristic pattern due to altitudinal variation, and rainfall (Arora, 1995).

The nature of soil profile, pH and nutrient cycling between the soils and trees are the important dimensions to determine the site quality. The vegetation influences the physicochemical properties of the soil to a great extent. It improves the soil structure, infiltration rate and WHC, Hydraulic conductivity and Aeration (Ilorker *et al.*, 2001; Kumar *et al.*, 2004). The large variation is soil vegetation due to their interaction and change in soil and vegetation characteristics with altitudes is commonly observed in the Himalayan forests. Thus, the hypothesis was made that; 1. How the altitudes affect the soil and vegetation with increasing altitudes, Therefore, the present study was taken in the *Pinus roxburghii* forest to understand, the effect of altitudes on soil and vegetation in Garhwal Himalaya.

## 2. Materials and Methods

The study area was located at 1100 - 1500 meter above sea level in the District Tehri Garhwal, Uttarakhand. The soil characteristics were analyzed by collecting five samples from 0-30cm depth at each altitude of *Pinus roxburghii* forest. The moisture (%), water holding capacity (WHC) and texture (%) of soil were determined as the methods described by Misra (1968). Soil pH was measured with dynamic digital pH meter. Soil organic carbon (SOC) was determined by the partial oxidation method (Walkey and Black, 1934). Total nitrogen (N) was determined using Kjeldahl methods (Jackson, 1958) and phosphorus (P) and potassium (K) by flame photometer methods (Jackson, 1958).

The phytosociological studies were carried in the tree and shrub layers by using 10m x 10m quadrat. A total of 10 quadrats was placed along transect at each altitude. The size and number of quadrats were determined as per species area curve (Misra, 1968) and the running means methods (Kershaw, 1973). The phytosociological attributes were calculated; as per the method described by Mueller-Dombois and Ellenberg (1974).

## 3. Results and Discussion

### 3.1 Soil characteristics

In the present study, three different altitudes of *Pinus roxburghii* forest were taken to assess soil nutrient status and its effect on species composition, structure and volume of *P. roxburghii* forest.

Among the physical properties, the lowest amount of moisture was in lowest altitude which increased with increasing altitudes but bulk density has shown a reverse trend with moisture which reduced with increasing altitude (Fig. 1). The water holding capacity increased with the increasing altitudes (Fig. 2). The soil texture was contributed by the highest proportion of sand followed by clay and silt in each altitude (Fig. 3).

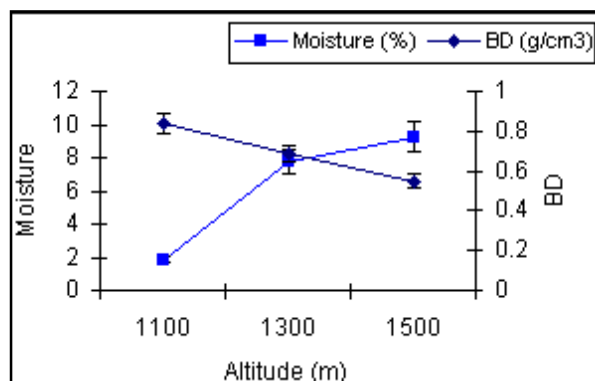


Fig. 1. Moisture and bulk density at different altitude.

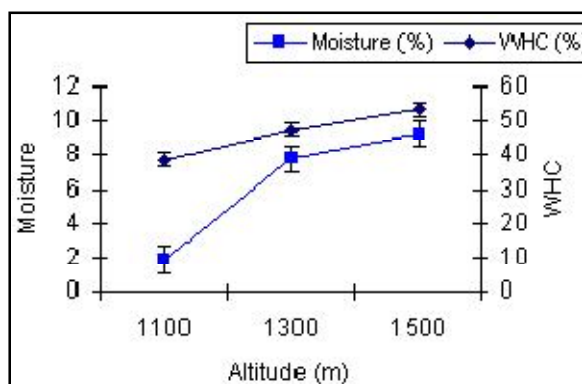


Fig. 2. Moisture and water holding capacity at different altitude.

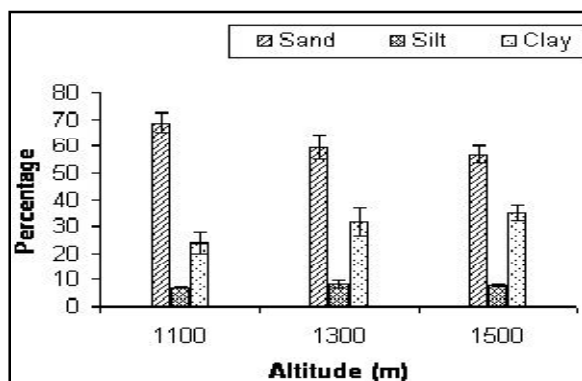


Fig. 3. Soil texture at different altitude.

Among the chemical characteristics of soil, pH of entire forest was acidic in nature. The soil organic carbon increased with increasing altitudes with the range from  $0.15 \pm 0.10\%$  to  $0.42 \pm 0.16\%$ . The nitrogen has also shown an increasing trend with the increasing altitudes (Fig. 4). The range value of phosphorus was from  $24.07 \pm 5.61$  kg/ha (1300m) to  $32.77 \pm 18.02$  kg/ha (1100m) (Fig. 5), while a range value of potassium was from  $159.04 \pm 54.97$  kg/ha (1100m) to  $203.09 \pm 43.54$  kg/ha (1300m) (Fig. 5).

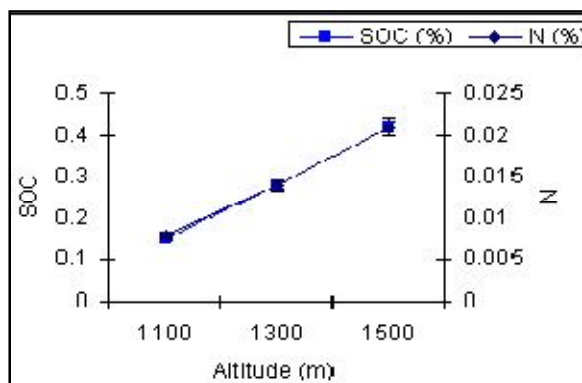


Fig. 4. Soil organic carbon and nitrogen at different altitude.

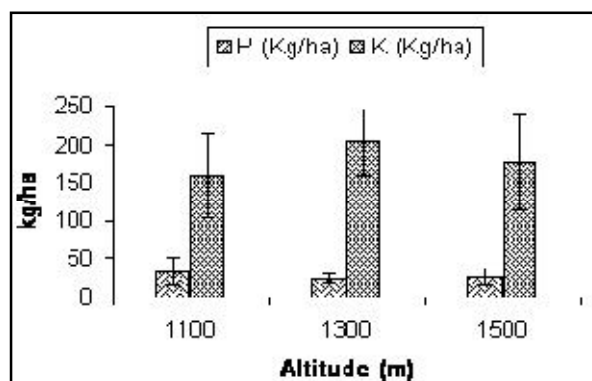


Fig. 5. Phosphorus and potassium at different altitude.

### 3.2 Species composition and structure

In entire forest, *Pinus roxburghii* was main tree species. The lower perennial shrub stratum was composed of *Rhus parviflora*, *Carissa opaca*, *Berberis aristata*, *Lantana camara* and *Rubus ellipticus*. Each shrub species were found with the association of *P. roxburghii* throughout the season of a year. The highest density (590 ind/ha) of *P. roxburghii* was at the top altitude and lowest (440 ind/ha) in middle altitude (Table 1), while total basal cover (TBC) reduced with increasing altitudes (Fig. 6). The volume of pine also followed a similar trend as total basal cover (Fig. 6). Among the associate species of *Pinus roxburghii* forest, maximum frequency and density was 50% (*Rhus parviflora* and *Berberis aristata*) and 220 ind/ha (*Carissa opaca* and *Berberis aristata*) respectively at lower altitude (Table 1) while maximum frequency and density was recorded for *Berberis aristata* at middle and top altitudes (Table 1).

### 4. Discussion

The soil pH ranged from  $6.30 \pm 0.31$  (1100m) to  $6.57 \pm 2.19$  (1300m). The acidic nature of the soil in Garhwal Himalayan forests has also been discussed by various workers (Bhandari *et al.*, 2000; Kumar *et al.*, 2005; Sheikh *et al.*, 2010). The soil organic carbon was increased with increasing altitudes might be due to higher amount of moisture percent, which is a good

indicator of higher soil organic carbon (SOC) in the soil. The lower BD at top altitudes is good indication that soils has occupied coarser structure of organic matter and enriches the spaces by soil organic carbon. Nitrogen also increased with the altitude. Phosphorus and potassium has not shown any trend with altitude. The water holding capacity reduced by reducing altitudes because higher bulk density in lower altitude has less pore space in the soil. The correlation coefficient among physical and chemical properties of soil with altitudes is shown in Table 2 and Table 3 respectively.

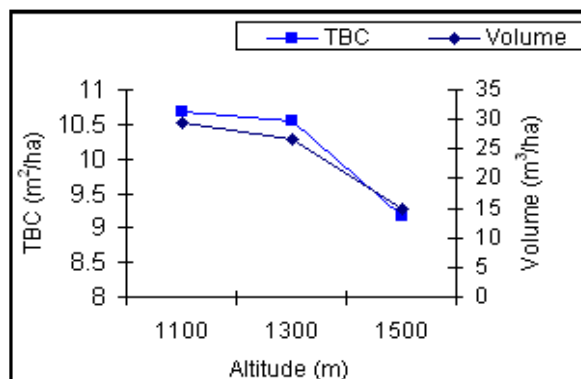


Fig. 6. Total basal cover and volume at different altitude.

### 5. Conclusion

The study concludes that the increasing moisture content and water holding capacity of soil with increasing altitude and reducing total basal cover and the volume of *Pinus roxburghii* with increasing altitude might be due to low input of litter and its slow decomposition, which is suppressed by factors such as low temperature, which suppresses microbial activities at high altitude results in slow decomposition of litter. Therefore, sufficient moisture and water retaining capacity of the soil also could not be helpful for increasing basal cover and volume of *Pinus roxburghii* forest with increasing altitude.

Table 1. Frequency (F) and density (D) of species in *Pinus roxburghii* forest.

| Species                  | Altitude (meters) |            |       |            |       |            |
|--------------------------|-------------------|------------|-------|------------|-------|------------|
|                          | 1100              |            | 1300  |            | 1500  |            |
|                          | F (%)             | D (ind/ha) | F (%) | D (ind/ha) | F (%) | D (ind/ha) |
| <i>Pinus roxburghii</i>  | 100               | 470        | 100   | 440        | 100   | 590        |
| <i>Rhus parviflora</i>   | 50                | 200        | 40    | 160        | 30    | 90         |
| <i>Carissa opaca</i>     | 30                | 220        | 30    | 110        | 40    | 120        |
| <i>Berberis aristata</i> | 50                | 220        | 70    | 270        | 80    | 260        |
| <i>Lantana camara</i>    | 20                | 70         | 20    | 50         | 10    | 30         |
| <i>Rubus ellipticus</i>  | 20                | 80         | 30    | 120        | 20    | 80         |

Table 2. Correlation coefficient among physical properties with altitude

|                         | Moisture (%)        | BD (g/cm <sup>3</sup> ) | WHC (%)             | Sand (%)            | Silt (%)           |
|-------------------------|---------------------|-------------------------|---------------------|---------------------|--------------------|
| BD (g/cm <sup>3</sup> ) | -0.950 <sup>*</sup> |                         |                     |                     |                    |
| WHC (%)                 | 0.972 <sup>*</sup>  | -0.997 <sup>*</sup>     |                     |                     |                    |
| Sand (%)                | -0.999 <sup>*</sup> | 0.960 <sup>*</sup>      | -0.979 <sup>*</sup> |                     |                    |
| Silt (%)                | 0.782 <sup>*</sup>  | -0.548 <sup>*</sup>     | 0.612 <sup>*</sup>  | -0.761 <sup>*</sup> |                    |
| Clay (%)                | 0.995 <sup>*</sup>  | -0.977 <sup>*</sup>     | 0.991 <sup>*</sup>  | -0.998 <sup>*</sup> | 0.713 <sup>*</sup> |

(\*Significant at 0.05 level of significance)

Table 3. Correlation coefficient among chemical properties with altitude

|           | pH                  | SOC (%)             | N (%)               | P (Kg/ha)           |
|-----------|---------------------|---------------------|---------------------|---------------------|
| SOC (%)   | 0.115               |                     |                     |                     |
| N (%)     | 0.115               | 1                   |                     |                     |
| P (Kg/ha) | -0.745 <sup>*</sup> | -0.748 <sup>*</sup> | -0.748 <sup>*</sup> |                     |
| K (Kg/ha) | 0.955 <sup>*</sup>  | 0.405               | 0.405               | -0.910 <sup>*</sup> |

(\*Significant at 0.05 level of significance)

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